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Analysis

The conservation against development paradigm in protected areas: Valuation of ecosystem services in the Doñana social–ecological system (southwestern Spain)

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ABSTRACT

The ecosystems of the Doñana social–ecological system (southwestern Spain) provide numerous ecosystem services to society. We valued the most important ecosystem services through a market-based approach, revealed-preference and stated-preference methods to assess the conservation effectiveness of the Doñana Protected Area, with consideration of existing human activities in surrounding lands. We also analysed the spatial distribution of the ecosystem services beneficiaries and the scale of their related markets. We found a clear trade-off between the local and global market values of ecosystem services because landscape management outside of the Doñana Protected Area promotes the provision of ecosystem services associated with international markets. Our results suggest that a *conservation against development* model occurs in the Doñana social–ecological system, in which land use intensification takes place outside of the Protected Area borders as a result of promoting marketed ecosystem services, while biodiversity conservation is the main activity inside the Protected Area. We conclude that protected areas should be part of a larger-scale, adaptive landscape management strategy in which conservation planning should be the focal element in coordinating sectoral policies in the context of social–ecological systems.

1. Introduction

Ecosystem service assessment has gained importance in the ecological and economic literature, especially since the publication of the Millennium Ecosystem Assessment (MA) (Fisher et al., 2008). Recently, a number of initiatives have attempted, with some success, to incorporate an ecosystem approach into policy making (e.g., TEEB, 2009, 2010). A key challenge in ecosystem management is determining how to manage trade-offs among multiple ecosystem services across landscapes (Bennett et al., 2009). The MA (2005) found that actions to enhance the supply of provisioning services, such as food and water, have led to declines in regulating services, such as erosion control or water purification, and cultural services, such as spiritual enrichment and aesthetic experiences. Thus, while the capacity of ecosystems to provide such services is undergoing serious degradation, the demand for these services is burgeoning as populations and standards of living increase (MA, 2005). This trend is due in part to a lack of approaches that value the diversity of ecosystem services and fully take them into account in environmental decision making. Additionally, the considerable lack of existing data on ecosystem service values (mainly regulating) forces decisions to be made between different land use options that are based on incomplete information, which causes the degradation of ecosystems (de Groot, 2006). Because of this, multi-functional landscapes are converted into simpler and mono-functional landscapes. As discussed herein, ecosystem services valuation represents a useful tool to quantify the trade-offs among different management options (Hicks et al., 2009) and improve knowledge about the social and political dimensions of ecosystem services management (Anton et al., 2010).

The main techniques employed by economists to estimate monetary value are based on three different approaches: (1) market-based approaches, which include techniques based upon current markets such as direct market analysis, production function analysis, and replacement or avoided costs; (2) revealed-preference approaches, which infer values from data on behavioural changes in real markets that are related in some way to the missing markets for the ecosystem, with the travel cost method and hedonic pricing being the main techniques used; and finally, (3) stated-preference approaches, which explore hypothetical markets through contingent valuation and conjoint analysis. For more details on economic valuation techniques, see Pearce and Moran (1994), NRC (2004), or Pascual et al. (2010).

During the 20th century, Protected Areas (PAs) became a cornerstone of conservation strategies to minimise the influence of humans on biodiversity (Pyke, 2007). The basic role of PAs is to protect charismatic species, which are generally large vertebrates that have popular appeal, from the outside socio-economic processes that threaten their existence. However, many PAs are not achieving their conservation objectives because their surrounding lands are being

Abbreviations: HCA, hierarchical cluster analysis; PA, protected area; RDA, redundancy analysis; SES, social–ecological system; WTP, willingness to pay.

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degraded or have suffered land-use intensification, thus promoting a paradigm of conservation inside PAs, but development outside of them (Hanssen and DeFries, 2007). From this point of view, rethinking the PA model is necessary (Phillips, 2003) looking for a more holistic approach able to integrate conservation into territorial policies outside of existing PAs (Bengtsson et al., 2003). Here, we used an ecosystem services valuation approach (i.e., a market-based approach, revealed-preference, and stated-preference methods) to evaluate the conservation effectiveness of PAs, including consideration of existing human activities in surrounding lands.

The main purpose of this report is to explore the socio-economic mechanisms underlying land use management outside and inside PAs that may influence ecosystems and, therefore, their capability to provide ecosystem services. To carry out this objective, we attempted to quantify trade-offs among ecosystem services in monetary terms associated with the management strategy used, i.e., inside and outside of the Doñana PA. Specifically, we (1) identified the main services provided by the ecosystems of the Doñana social–ecological system (SES); (2) estimated the monetary value of these ecosystem services; (3) analysed the spatial scale at which these ecosystem services were used, enjoyed, or valued by users; and (4) explored the relationship between ecosystem service values and the management strategy used, i.e., inside and outside of the Doñana PA.

In this study, we used the SES perspective to quantify trade-offs in ecosystem services values associated with different management regimes: conservation inside the PA and development outside the PA. We conceptualised the Doñana region (south-west Spain) as a coupled human and natural system, in which we assumed that both the PA and the territorial matrix outside the PA are embedded in complex SESs (Ostrom, 2009).

2. The Doñana Protected Area as a Social–Ecological System

The Doñana region is located at the end of the Guadalquivir watershed in Andalusia on the southwestern coast of Spain (Fig. 1). Far from being a pristine and virgin natural environment, Doñana is greatly influenced by the different uses of its territory that have occurred throughout its history (Ojeda, 1987). The ancient practices, such as agriculture, forestry, grazing or fire management, that have taken place in this region lead us to describe it as a cultural landscape where nature and society have co-evolved over centuries (Gómez-Baggethun et al., 2010). The biophysical system of Doñana consists of four ecodistricts: marshes, aeolian sheets, coastal system, and the Guadalquivir Estuary (the largest estuary in the Gulf of Cadiz), which are referred to as the Greater Fluvial–Littoral Ecosystem of Doñana (220,070 ha) (Montes et al., 1998). These ecodistricts represent a rich natural area, which makes Doñana unique in many respects: it is a major stepping-stone in the migration route for birds migrating between Europe and Africa; it is home to the most endangered mammal in the world, the Iberian lynx (*Lynx pardinus*), as well as many endemic and threatened species; and it contains what may be the most significant wetland in Europe (García Novo and Marín Cabrera, 2006).

Regarding the socio-cultural system in this region, the Doñana SES is administratively organised by 16 municipalities with a population of nearly 213,839 inhabitants (involving a low population density: 0.65 inhabitants ha^{-1}), whose activities are devoted to agriculture and tourism. The history of the Doñana SES reflects a continuous process of human landscape transformation (Ojeda, 1992). Agriculture has historically been the subsistence base of the region; in fact, until around 1940, the economy of the Doñana SES was largely dependent on local provisioning services.

During the last several decades, different forestry, agriculture, and tourism policies started to transform the ecosystems of Doñana. In 1941, the Forestry district of south-east Huelva was declared to be of national interest, as it was associated with developing forestry monocultures of fast-growing species. In 1960, 74,400 ha of marshes located on the left bank of the Guadalquivir river were transformed into arable lands through the "Irrigation Area of the Lower Guadalquivir" project, entailing the construction of several colonisation settlements and causing a profound landscape change. On the right bank of the Guadalquivir river, the Spanish government approved the Almonte-Marshes irrigation plan in 1971. This plan attempted to transform 46,000 ha into irrigated lands. In 1968, the urban centre of the Matalascañas resort was declared a Centre of National Tourist Interest, increasing tourist activity. Currently, Matalascañas has less than 2000 permanent inhabitants, but the population increases to 300,000 in summer, thus showing a strong seasonal occupation pattern (García Novo and Marín Cabrera, 2006). To counteract these trends, it was declared a National Park in 1969 by the Spanish Government, and in 1989, its surroundings were declared a Natural Park by the Andalusian Government. The Doñana National Park is strictly protected, and only a few types of low-intensity traditional activities are allowed. The Doñana Natural Park was initially created to buffer human impacts on the National Park, and different traditional practices are allowed there (i.e., forestry, cattle ranching, game hunting, and agriculture in some areas). In 2005, the two Parks were unified under the protection status of a Natural Protected Area. Currently, 29.1% of the area of the SES is protected under this protection status. Moreover, its international importance was recognised by the International Biosphere Reserve in 1980, by the Ramsar Convention in 1982, and by UNESCO in 1995.

Although the Doñana PA serves a critical role in biodiversity conservation, it is embedded in a matrix of intensive land uses. Therefore, conflicts have increased between biodiversity conservation and economic development with the expansion of agriculture, tourism, and urbanisation projects (García Novo and Marín Cabrera, 2006).

3. Methodology

We calculated the value of ecosystem services provided by the Doñana PA through the estimation of the following: (1) the direct consumptive use value, (2) the direct non-consumptive use value, (3) the indirect use value, and (4) the existence value, which is defined here as the moral satisfaction obtained from biodiversity conservation (Kahneman and Knetsch, 1992). It is important to note that these values should be mutually exclusive; if not, double-counting among the various components can occur. The different methods used to quantify each type of ecosystem service value are outlined in Table 1. When the data source was based on questionnaire surveys, the population sampled was randomly selected in an attempt to cover a wide range of backgrounds (see Fig. 1 for sample points). In all cases, the questionnaires were pre-tested.

All obtained values were converted to 2008€ (1 € = 1.2528 $) using the Consumer Price Index and are given in 2008€ regardless of the date to which they refer. When we had a temporal series of data, we estimated the average value of the total benefits in 2008€.

3.1. Provisioning Services: Consumptive Use Values

Consumptive use values were derived from published and unpublished data and through interviews of key informants and landowners. Specifically, we used the following as data sources (Table 1): (1) the official statistical data of the Department of Agriculture and Fisheries of the Andalusian Government covering the years 2001–2008; (2) the annual reports of the activities of the Doñana PA developed by the Spanish Ministry of Environment and the Department of Environment of the Andalusian Government during the years 2001–2008; and (3) semi-structured interviews administered to 24 landowners and key informants. The interview survey was conducted during 2006 using snowball sampling, i.e., asking key informants to name other people who should be contacted by researchers. This interview was structured

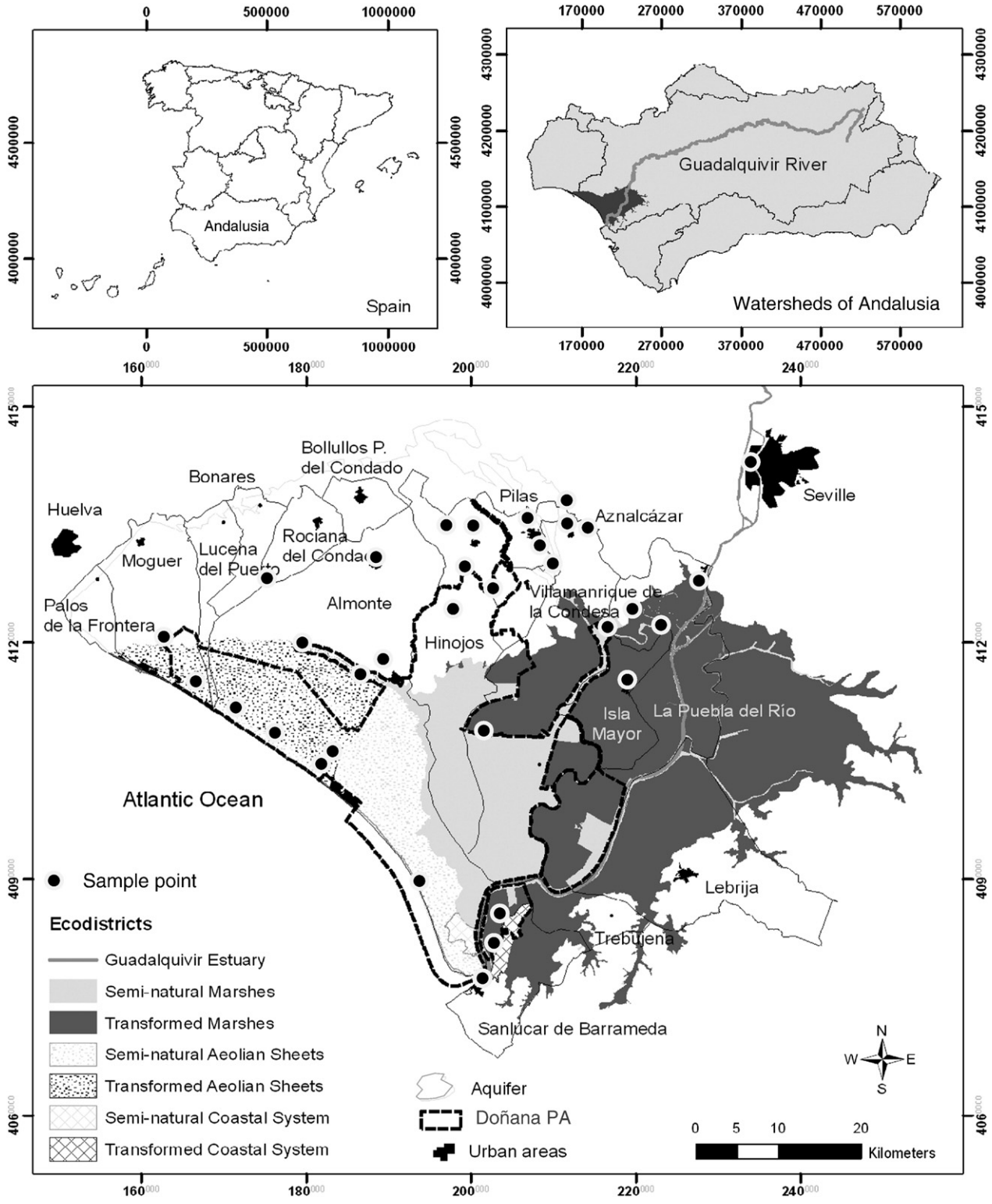

Fig. 1. Map of the Doñana social–ecological system showing the location of the sampling points. The ecodistricts represent the biophysical limits of Doñana (i.e., the service providers); the municipalities correspond to the limits of the main ecosystem services users; and the limits of the Doñana PA represent the conservation administrative limits.

into the following sections: (1) general questions about the interviewee's profession, residence time in the Doñana SES, and knowledge of Doñana, (2) provisioning service exploitation, (3) net profit received and economic value of this service in local markets, (4) perceived trend of provisioning service in the last decade, and (5) other people or organisations that have in-depth knowledge about the provisioning service.

3.2. Regulating Services: Indirect Use Values

Regulating services were estimated through a contingent valuation study through willingness to pay (WTP) estimations. A survey was designed to explore users' preferences for maintaining regulating services. The survey was conducted from July, 2008 to March, 2009 by direct face-to-face questionnaires, obtaining a total sample of 477

Table 1
The ecosystem services provided by the Doñana social–ecological system (SES), their type of value, and the methodology used for their estimation. (ES: ecosystem service).

ES type	Type of value	Ecosystem service	Estimation method	Year assessed	Source
Provisioning	Consumptive direct use value	Agriculture Fishing (estuary and marshes)	Market based	2001-2008	■ Agriculture and Fisheries Statistics Yearbook of Andalusia ■ Interviews
		Cattle	Market based	2004-2008	■ Annual Reports of Activities of the Doñana PA
		Coastal shell-fishing		2001-2008	■ Interviews
		Forest resources		2001-2008	
		Crayfish	Market based	1999-2006	■ CAP (2001) ■ Interviews
Regulating	Indirect use value	Soil fertility Erosion control Water quality Hydrological regulation Micro-climatic regulation	Contingent Valuation (WTP)	2008	■ Questionnaire survey from July 2008 to March 2009
Cultural	Non-consumptive direct use value	Tourism	Travel cost method	2004	■ Questionnaire survey (Martín-López et al., 2009a)
		Religious tourism (spiritual values)	Travel cost method	2004	■ Questionnaire survey (Martín-López et al., 2009a)
		Research	Research budget	2003-2008	■ Martín-López et al. (2009b) ■ The Doñana Biological Station Reports
		Environmental education	Environmental education budget	2006-2008	■ Annual Reports of Activities of the Doñana PA
	Existence value	Moral satisfaction for conserving biodiversity	Contingent valuation (WTP)	2004	■ Questionnaire survey (Martín-López et al., 2007b)

respondents. The population sampled was randomly selected with the aim of covering a wide range of backgrounds involving residents in the study area, workers (i.e., natural protected area managers), and the tourist population. The sampling population was restricted to citizens 18 years of age and older. Sampling was conducted at different sample points, including the PA offices, PA visitor centres, public spaces within local villages, city halls, recreational areas, agrarian offices, and agricultural fields (Fig. 1). A total of 404 questionnaires were used in the economic valuation exercise because we censured WTP results using the Kaplan–Meier survival curve when the probability of the respondents agreeing to give money was less than 2% and because of incomplete questionnaires. We used the Heckman model, as has previously been used in contingent valuation studies in the Doñana SES (e.g., García-Llorente et al., 2008; Martín-López et al., 2007a). We selected the best model from all possible combinations of variables guided by Akaike information criterion statistics (Burnham and Anderson, 2002).

Additional details about the questionnaire design of the contingent valuation exercise and the final variables used in the Heckman model are presented in Appendix A.

The results obtained from the Heckman model were analysed through ANOVA tests to determine statistical differences among specific regulating services.

3.3. Cultural Services: Non-Consumptive Use and Existence Values

We estimated the non-consumptive use value of tourism and religious values (Pilgrimage of El Rocío) through a travel cost method. The values of research and environmental education services were obtained from annual budgets, and the values related to the satisfaction for conserving biodiversity were calculated through the contingent valuation method.

Data on the total number of tourists were obtained from Gómez-Limón García et al. (2003), and expenditure data were estimated on the basis of a questionnaire survey conducted during February–October, 2004. A total of 672 questionnaires were completed, representing 3965 visitors. We estimated the value of tourism and religious services by the individual travel cost method (for more details, see Martín-López et al., 2009a).

Following the method of Hicks et al. (2009), we calculated the values of research and environmental education services from annual budgets, which can be used as an estimator of the socio-economic importance of these services (Table 1). Information on the size of research budgets was obtained from the official Spanish Gazette and the Doñana Biological Station reports (http://www.ebd.csic.es/) from 2003 to 2008. Additionally, we carried out interviews of scientists conducting research projects in Doñana. Environmental education budgets were obtained from annual reports on activities in the Doñana PA over the years 2006–2008.

The individual satisfaction related to biodiversity conservation was investigated in a contingent valuation survey carried out from February to October 2004 (for more details, see Martín-López et al., 2007b). Although the total sample for these contingent valuation exercises included 672 respondents, the final dataset was reduced to 649 respondents because some individuals did not answer all of the questions in the survey.

3.4. Analysis of Trade-Offs Among Beneficiaries and Spatial Scales

Ecosystem services were classified based on the scale at which the beneficiaries used, enjoyed, or valued them (Hein et al., 2006). For those ecosystem services that we analysed through contingent valuation, we used an ANOVA test to explore the influence of the spatial scale on economic value. Additionally, when the services were locally marketed within the Doñana SES and its surroundings, we designated them as being associated with 'local markets'. When the benefits were globalised, we referred to the value of ecosystem services as associated with 'global markets', which refers to national and international markets. Furthermore, we classified the services based on their biophysical provider, i.e., their main ecodistricts, and based on the conservation limits, i.e., if the service was supplied inside the PA or outside its borders (Fig. 1). We applied Student's *t* tests and ANOVA tests to compare the values of services provided inside to those supplied outside the PA and among different scales of beneficiaries, respectively. The Shapiro–Wilk test was used to check normality (Shapiro and Wilk, 1965).

We used a redundancy analysis (RDA) to examine how economic values were related to the following: (1) the ecosystem service provider (i.e., ecodistricts); (2) management strategy (if the service

was provided inside or outside the PA); (3) the spatial scale of beneficiaries; and (4) the scale of the markets. A Monte Carlo permutation test (1000 permutations) was used to determine the significance of the explanatory variables in the explanation of ecosystem service values.

A hierarchical cluster analysis (HCA) was carried out to identify different groups of ecosystem services based on their economic value. The HCA was performed using those factors obtained in the RDA to guarantee the absence of correlations between factorial scores, and as agglomerative techniques, we used the Euclidean distance and Ward's method.

Here, our calculations simplify the complex issue of ecosystem services valuation because we used conceptually different indicators of value (consumers' surplus, value added, and budget invested).

4. Results

4.1. Provisioning Services: Consumptive Use Values

4.1.1. Agriculture

The agriculture in the study region involves both so-called "new agriculture" (i.e., strawberry greenhouses and rice fields) and "traditional agriculture" (i.e., vineyards, and olive groves). Although the agricultural area in the Doñana SES increased throughout the entire 20th century, some traditional crops have been declining in area because of land conversion to intensive agriculture. Appendix B shows the main characteristics of these services.

4.1.1.1. New Agriculture. The strawberry cultivation area (*Fragaria ananassa* Duch.) in the Doñana SES was approximately 4970 ha in 2007. Currently, this region represents an average of 60% of the total Spanish production and is the top region in the world for harvesting strawberries. Between the years 2001 and 2007, the average production was 198,647 metric tonnes (t), which was almost exclusively destined for export, mostly to France and Germany (62% of the total exports) (CAP, 2009a). The average income received per farmer in 2008 was 1.06 € kg^{-1}, and the public subsidies were 3.6 € ha^{-1} $year^{-1}$. The average production costs were 24,500 € ha^{-1} $year^{-1}$. The strawberry industry produced a net value of 117.3 million € in 2008 (91.1 million € $year^{-1}$ from 2001 to 2007). These estimates are based on limited data because there is very little quantitative information about the areas illegally occupied by strawberry crops.

The rice (*Oryza sativa*) cultivation area was approximately 17,900 ha in 2008. During the last two years, there was a considerable reduction in the rice area because of adjustments in the authorised water volume used due to drought. During the years 2001–2008, the average rice area was 26,000 ha. An average of 208,133 t $year^{-1}$ were farmed between 2001 and 2008, with a gross benefit of 49.3 million € per annum. Since 2005, farmers additionally received approximately 1670 € ha^{-1} as public subsidies (within the framework of the Common Agricultural Policy, Regulation EC1782/2003). Furthermore, since 2003, if farmers employed integrated production, they also received 398 € ha^{-1} (Regulation EC/1257/1999). The average cost for the rice fields was approximately 1496 € ha^{-1} (CAP, 2007). Therefore, the average net value of rice production between the years 2001 and 2008 was approximately 63 million € $year^{-1}$. Of the total production from Doñana, approximately 54% is exported to European countries (CAP, 2007).

4.1.1.2. Traditional Agriculture. The vineyard analysed in this study corresponded to the Designation of Origin *Condado de Huelva* and was comprised of the autochthonous grape variety *Vitis vinifera* cv. *zalema.* In contrast to new crops, the vineyard area suffered a considerable decrease in the last two decades (−132%) because of the low prices of grapes, subsidies for removed vineyards, grapevine ageing (53% of the vineyard area existed prior to 1956), and fungal diseases (Polonio Baeyens et al., 2005). The majority of farmers in the region (95%) are smallholders, with 69% of farms being less than 2 ha. Between the years 2001 and 2008, the average production was 33,957 t, yielding an estimated net average value of 247.4 €. Despite their low profitability, these vineyards continue to be maintained because the farmers have a strong sense of place, and they have preserved their social capital through familiar cooperatives. In 2007, the Common Market Organisation (i.e., the basic element of the EU Common Agricultural Policy to develop a common market for agriculture products) agreed to reform wine production in Europe with the purpose of achieving a balanced market. This reform entailed a subsidy over 3 years to remove the surplus and uncompetitive wine production (Regulation EC/479/2008). In this context, the Andalusian Royal Decree 1244/2008 established a subsidy of 1740 € ha^{-1} to uproot the vineyards in farms of less than 20 ha. The purpose of this measure was to promote the abandonment of traditional wine production, and it entailed a land use change to intensive crops (such as strawberries). This change has affected hydrological regulation due to soil erosion, causing marsh sedimentation, increasing water extraction from aquifers, and diminishing refuge habitats for cynegetic species (CMA, 2009).

The olive grove cultivation area in the Doñana SES was approximately 13,469 ha in 2008, of which 63% was unirrigated (CMA, 2009). In 2008, approximately 18,836 t of olives were farmed, with a gross benefit of 24.8 million € per annum. Spain is the top olive oil exporting country. The main markets of the olive oil produced were Italy, France, Portugal, and the United States of America (USA). In contrast, for table olives, the main markets were the USA, Russia, and Italy (see Appendix B; CAP, 2009b).

4.1.2. Livestock

The livestock in the Doñana PA are mainly comprised of three autochthonous breeds: the feral cattle of the *Retuertas* horse, the *Mostrenca* cow, and the Andalusian churra sheep (Calderón, 2008). Cattle farming has historically been rooted in the local population of the Doñana SES and has been an important income source in the past (Murphy and González Faraco, 2002). Currently, its economic importance has been substituted by its cultural value (Calderón, 2008). A tradition that started in 1504 takes place every 26th of June: the Mares' Roundup. Here, horses that graze in the marshes are herded together and driven to the El Rocío and Almonte villages to have their manes and tails trimmed and their foals sold. Additionally, these feral livestock have an important ecological value because of their genetic isolation (Calderón, 2008; Vega-Plá et al., 2006). Since 2000, the management of cattle has been governed by the Cattle Use Plan, which authorised 2485 UGM (large animal units). Between the years 2004 and 2008, the average numbers of animals per year were: 1523 (horses), 932 (cows), and 579 (sheep). Based on the mean annual price established in the Andalusian statistics for these cattle species, their average economic value was approximately 2.3 million €.

4.1.3. Fishing

4.1.3.1. Fishing in the Guadalquivir Estuary. Two main fisheries are located in the Guadalquivir Estuary: the glass eel (*Anguilla anguilla*) and white shrimp (*Palaemon longirostris*) fisheries (Appendix B). The glass eel populations in the Guadalquivir River suffered a decline of 95% over the last three decades. Thus, a reduction of 95% of captures took place between 1992 (44 t) and 2008 (0.3 t) due to pollution (organochlorine pesticides from the surrounding agricultural area and heavy metals) (Sobrino et al., 2005). Our interviews showed that in 2006, 217 fishermen caught 1953 kg of glass eel and 39,060 kg of white shrimp, with a total value of 0.61 and 12.1 million € per annum, respectively. In the last decades, fishermen have also started to collect the estuarine bivalve *Scrobicularia plana* because of increasing commercial interest in this species and the reduction in glass eel populations.

Fishing for both species (glass eel and shrimp) is carried out with the same type of boat and uses the same local fishery gear ("persiana"

nets). Small mesh nets are needed to catch glass eel and shrimp (≅1 mm for glass-eel; ≅5 mm for white shrimp). These net sizes affect the estuary's nursery functions due to larger catches of larvae and juveniles of marine fish (Sobrino et al., 2005). The reported annual catch between the years 2000 and 2008 in the fish market of Bonanza (in Sanlúcar de Barrameda) was 2956 t, with an annual value 14.5 million € per annum. Of this, 1032 t and 8.2 million € are related to species that use the Guadalquivir Estuary as a nursery ground (Appendix B). During this decade, the number of individuals in these catches suffered a reduction of 20%, representing a loss of 33% of their commercial value.

4.1.3.2. Fishing in the Marshes. The red-swamp crayfish (*Procambarus clarkii*) is the main fishery resource found in the Doñana marshes. Since the introduction of *P. clarkii* to the Guadalquivir marshes in 1974, a progressive increase in their capture has taken place, which was followed by a subsequent price decline. At the end of 1970s, people paid approximately 7.9 € kg^{-1}, and in 1982, the average price was 1.9 € kg^{-1} (Molina, 1982), which decreased in 1999 to 0.7 € kg^{-1} (CAP, 2001). From the interviews carried out in 2006, the price of crayfish increased slightly (1.1 € kg^{-1}). Similarly, the number of professional fishermen decreased during this period. Although 408 fishermen were authorised to fish in 1987, only 170 were authorised in 2001 (CAP, 2001), and in 2006, this number was only 130. The monetary value obtained by the local fishermen in 2006 was 1.8 million €. During the last 2 decades, both the number of individuals caught and their economic value suffered a decrease, 73% and 194%, respectively, because of the reduction in price and the number of professionals. Approximately 46% of the catch was exported to other locations in Spain, and 42% was exported to France, the Scandinavian countries, and the United States (CAP, 2001).

4.1.4. Coastal Shell-Fishing

The commercial coastal shellfisheries in the region are focused on *Donax trunculus*, which is currently managed by the Andalusian Order of September 24, 2008. On average, the *D. trunculus* population density along the Doñana coasts is 16.64 ± 10.46 individuals m^{-2} (Doñana National Park, 2002). Although the maximum number of commercial fishermen permitted is 160, the average number of fishermen per day is 78. The maximum authorised number captured is 25 kg day^{-1} $fisher^{-1}$ over 205 days $year^{-1}$. Therefore, the *D. trunculus* harvest reaches a maximum of approximately 350 t $year^{-1}$, generating an average of 1.5 million € $year^{-1}$. These captures were usually consumed by local users (Appendix B).

4.1.5. Forest Resources

The forests of the Doñana SES cover approximately 67,608 ha, which are managed by the Department of Environment of the Andalusian Government. Since 2004, 1770 m^3 of timber was collected inside the PA on average, yielding a total income of 64,479 €. In 2004, a total of 1446 m^3 of timber was harvested, declining to 1264 m^3 in 2008. Most of this timber comes from *Pinus pinea* (stone pine), while approximately 0.5% comes from an invasive alien species, *Eucalyptus camaldulensis* (river red gum).

The main non-timber forest products harvested in the Doñana PA are pine cones and honey. Pine cones are harvested from *P. pinea.* Although 1,066,493 kg of pine cones was harvested in 2004, in 2008, the amount was 491,720 kg. In 2004, the value associated with pine cone harvesting was 134,398 €, and in 2008, the value was 27,600 €. This considerable reduction was due to the poor harvest in 2007 and 2008.

With respect to honey production, in 1999, the Department of Agriculture and Fisheries of the Andalusian Government registered 11,080 hives distributed over 4 municipalities (Appendix B). Of these, 4640 hives were distributed inside the PA in 2008. Since 2000, hives have yielded 15 kg $year^{-1}$ of honey on average, which retails at approximately 1.4 € kg^{-1}. The average total production of honey from 2001 to 2008 was estimated to be 79.4 t $year^{-1}$, and the average total value was 121,256 € $year^{-1}$.

Since 2000, the production of honey has suffered a considerable decline because of the colony collapse disorder symptom (Higes et al., 2005; Stokstad, 2007) and the eradication of practically all *Eucalyptus* spp. as part of the invasive alien species management plan in the Doñana PA. *E. camaldulensis* constitutes an important source for nectar, pollen and honey production (Andrés et al., 2006). Other nectar-producing plants in Doñana are presented in Appendix B.

4.2. Regulating Services: Indirect Use Values

We found significant differences in individuals' perception of the importance of specific regulating services (ANOVA test, $F = 13.03$, p-value < 0.0001). The regulating services that were most highly valued by respondents were water quality and climate control, and the less valued was soil fertility (Table 2). Overall, the estimated economic value of regulating services was approximately 62 million 2008€. Appendix A shows the results of the Heckman model.

Additionally, significant differences existed among the spatial scales at which beneficiaries enjoyed these services (Table 2). Specifically, we found significant differences for soil fertility, erosion control, and micro-climatic control. While local people expressed a higher WTP for maintaining soil fertility, Andalusian people expressed a higher WTP for maintaining erosion control. Furthermore, people from Andalusia and those at the international scale (i.e., mainly tourists coming from other European countries) preferred control of climate change. Water and air quality as well as hydrological regulation were valued by beneficiaries at all spatial scales. Thus, water quality and hydrological regulation could be perceived as important services by all users due to the water stress problem in Doñana.

4.3. Cultural Services: Non-Consumptive Use Values

4.3.1. Recreational and Tourism Services

The Doñana SES is an exceptional area for tourism, with four distinct types of tourist activities taking place: nature, 'sun and beach', cultural, and religious activities (Martín-López et al., 2009a). More than 4 million tourists visit the Doñana SES each year (Gómez-Limón García et al., 2003). The average consumer surplus for nature, 'sun and beach', cultural, and religious tourists was 36.8 €, 35.7 €, 14.2 €, and 86.3 € per annum, respectively, resulting in a total estimation of 126 million € (for more details, see Martín-López et al., 2009a).

4.3.2. Environmental Education and Scientific Knowledge Services

In the Doñana PA, environmental education and research represented only 7% of the total investment in 2008. During the years 2006–2008, an average investment of 667,516 € was directed toward environmental education, representing an increase of 75%. Similarly, in 2003, scientific investments increased by 39%, and the number of scientific projects increased by 18%. Between 2003 and 2008, the average allocation of funds was 1.5 million € per annum, covering an average of 85 scientific projects per year.

4.3.3. Satisfaction Related to Biodiversity Conservation

Martín-López et al. (2007b) found that more than 65% of users felt satisfaction related to conserving biodiversity and were willing to pay 36.04 € per annum for species protection. People were more willing to pay for conserving charismatic species, i.e., the Iberian lynx and the Spanish imperial eagle (*Aquila adalberti*), which are two species endemic to the Iberian Peninsula that have become very scarce. In fact, the declarations of both the Doñana Biological Reserve in 1964 and the Doñana National Park in 1969 were based mainly on the

Table 2
Effect of spatial scale on ecosystem service values. Mean scores and *F*-values (ANOVA) for WTP (2008€ year^{-1}) per ecosystem service at different spatial scales of beneficiaries are shown. Standard deviation is shown between brackets.

Ecosystem service	Total sample	Spatial scale of beneficiaries					F^a
		Local	*Huelva–Seville–Cadiz*	*Andalusia*	*National*	*Intern.*	
Water quality	13.98 (30.65)	15.45 (29.75)	11.88 (17.26)	18.60 (27.49)	11.63 (16.40)	12.12 (16.55)	0.79
Micro-climatic control	8.52 (12.75)	4.35 (7.69)	8.64 (12.53)	12.55 (15.54)	7.86 (11.70)	9.38 (12.60)	4.54***
Air quality	7.56 (14.15)	7.60 (20.48)	7.33 (12.52)	8.09 (11.67)	7.00 (11.17)	7.74 (11.67)	0.07
Erosion control	7.45 (15.63)	3.39 (9.58)	8.10 (12.98)	11.19 (25.48)	6.88 (11.21)	7.88 (13.20)	2.68**
Hydrological regulation	6.20 (15.06)	4.40 (10.01)	7.44 (13.38)	7.36 (24.39)	5.94 (10.55)	5.99 (12.66)	0.56
Soil fertility	5.16 (12.95)	7.92 (20.64)	3.16 (9.25)	5.01 (11.08)	6.23 (10.23)	3.35 (8.82)	1.98*
Satisfaction related to biodiversity conservation	30.80 (14.03)	43.55 (18.16)	33.71 (11.43)	29.42 (9.32)	23.10 (7.56)	19.80 (6.4)	75.03***

[a] Statistical significance at the *** = 1%, ** = 5%, and * = 10% levels.

presence of the Iberian lynx and the Spanish imperial eagle (Valverde, 1960).

We also found that the second major factor influencing WTP for biodiversity conservation was the users' origin. The WTP amount declined with the geographical distance between the user's place of residence and the Doñana, which was probably because of the local identity factor. The ANOVA test showed that local people were more willing to pay for biodiversity conservation than Andalusian, Spanish or international beneficiaries (Table 2).

4.4. Trade-Offs Between Ecosystem Services at Different Spatial Scales

Table 3 summarises the mean economic values obtained for all ecosystem services and the scale at which they were used.

The RDA explained 97.9% of the variation of service values (Fig. 2). The x-axis (RDA1) represented 89.7% of the variation, showing a gradient from higher economic values (positives scores of RDA1) to lower values (negative scores of RDA1). The y-axis (RDA2), representing 8.2% of the variation, showed a difference between beneficiaries at the local scale (positive scores) and the larger scale (negative scores). The RDA showed a trade-off between local and global market values (Fig. 2). Local and lower values included traditional provisioning services, such as cattle, pine cone harvesting, and beekeeping; environmental education; or regulating services enjoyed at local scale, such as soil fertility. In contrast, higher service values were mainly associated with monetary value derived through international markets (e.g., agriculture and fisheries) and national-level markets (e.g., tourism) (see Table 3). Thus, we found significant differences in the ecosystem service values (€ ha^{-1} year^{-1}) among the different spatial scales of beneficiaries (ANOVA-test, $F = 5.58$, p-value = 0.005), with the international scale having significantly higher values than local scales (Bonferroni post-hoc test, p-value = 0.008).

Table 3
Mean estimated ecosystem services values in 2008€ ha^{-1} year^{-1}; the ecosystems in which they were provided; if they were provided inside the PA; and their related beneficiaries and markets at different scales. (PA: the ecosystem service is provided inside the Protected Area).

Ecosystem service	Mean value (€ ha^{-1} year^{-1})	Ecodistrict				PA	Scale of ecosystem services beneficiaries				Market	
		Aeolian sheets	*Marshes*	*Coastal*	*Estuary*		*Local*	*Andalusian*	*National*	*International*	*Local*	*Global*
Provisioning services												
Agriculture (strawberry)	1804.8	×							×	×		×
Agriculture (rice)	396.6		×						×	×		×
Agriculture (vineyard)	5.1	×						×	×			×
Agriculture (olive groves)	479.7	×						×	×	×		×
Cattle	14.4		×			×	×				×	
Estuary fishing[a]	1594.5				×				×	×		×
Estuary fishing (nursery)[b]	1190.1				×		×	×	×	×	×	×
Crayfish fishing	15.3		×						×	×		×
Coastal shell-fishing	391.2			×		×	×				×	
Timber	1.3	×				×	×				×	
Pine cone harvesting	1.6	×				×	×				×	
Beekeeping	2.4	×				×	×				×	
Regulating services												
Water quality	104.6	×	×		×	×	×	×	×	×	×	
Micro-climatic control	56.4	×	×			×		×	×	×		×
Air quality	188.0	×				×	×	×	×	×	×	
Erosion control	38.9	×	×			×		×		×	×	
Hydrological regulation	26.1	×	×		×	×	×	×	×	×	×	
Soil fertility	20.6	×	×				×				×	
Cultural services												
Nature tourism	198.7	×	×		×	×			×	×		×
Beach tourism	1680.6			×		×		×	×			×
Cultural tourism	427.9	×	×		×				×			×
Religious tourism	904.5	×	×		×	×	×	×			×	×
Scientific values	6.7	×	×		×	×		×	×			×
Educational values	3.0	×	×		×	×	×				×	
Satisfaction related to biodiversity conservation	485.8	×	×	×	×	×	×				×	

[a] Although fishing for glass eels has decreased by 95%, the capture of white shrimp and *Scrobicularia plana* has increased.
[b] Species that use the Guadalquivir Estuary as a nursery ground.

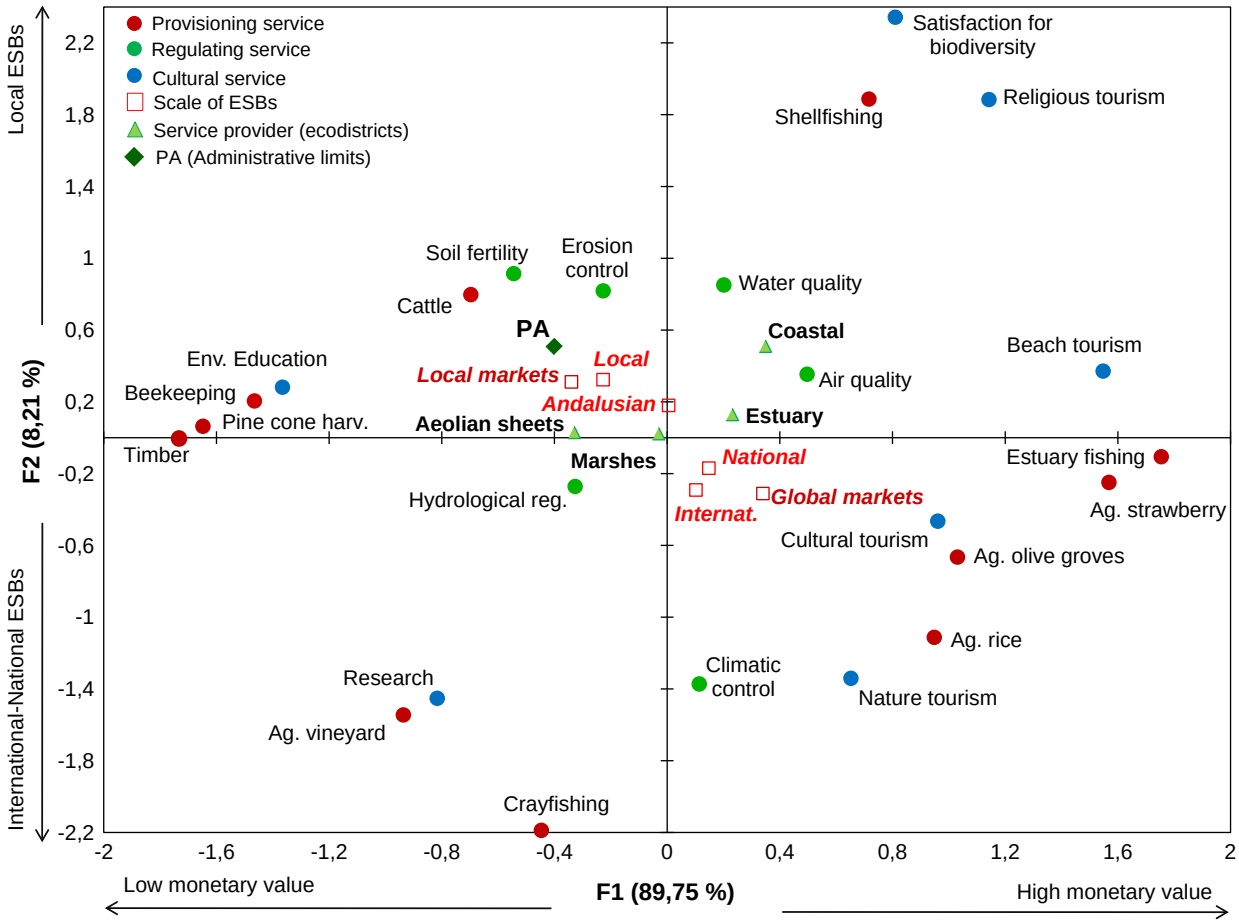

Fig. 2. Redundancy analysis of ecosystem services driven by their economic value (€ year^{-1} ha^{-1}) related to the provision of ecosystem services (ecodistricts and the PA), the scale of ecosystem service beneficiaries (ESBs), and their related markets. The x-axis (RDA1) represents 89.7% and the y-axis (RDA2) 8.2% of the variation. The economic values were log (natural) transformed, and the ordination was value centred and standardised.

Furthermore, Fig. 2 also shows that those ecosystem services provided inside the PA borders had lower values than those supplied outside, and Student's *t*-test showed that this difference was significant (Student's *t*-test, $t_{23} = 2.12$, *p*-value = 0.045).

The PA variable was related to those ecosystem services used by local beneficiaries, which were associated with local markets and low monetary value, i.e., traditional provisioning services, erosion control, soil fertility, hydrological regulation, and environmental education (Fig. 2). Therefore, the ecosystem services provided inside the PA have lower monetary value than those delivered outside its borders, which are also used by national and international beneficiaries in global markets.

Three groups of ecosystem services were identified by HCA with a dissimilarity coefficient of 0.52 (Fig. 3). The first group was composed of the provisioning and cultural services of high monetary value derived from international markets. The second group was composed of all regulating services, traditional provisioning services (i.e., cattle, timber, pine cone harvesting, and beekeeping), and environmental education, which have lower economic values and are provided inside the PA. Finally, the third group was composed of those ecosystem services with high economic values that are used at local and Andalusian scales (i.e., shellfishing, religious tourism, and satisfaction related to biodiversity). At the highest coefficient of dissimilarity, two different clusters were found: the first cluster represented the marketed ecosystem services (e.g., agriculture, fisheries, and tourism) that are provided outside the PA borders, and the second cluster included groups 2 and 3 (i.e., regulating and traditional provisioning services, and the satisfaction for biodiversity conservation) (Fig. 3). These results suggest that a *conservation against development* model occurs in the Doñana SES in which land use intensification takes place outside the PA borders as a result of promoting marketed ecosystem services, whereas biodiversity conservation, regulating services, and traditional practices are the main activities inside the PA.

5. Discussion

5.1. The Effect of the Conservation Against Development Model in Ecosystem Services Provision

The ecosystem services approach allows a better understanding of the degradation of nature when land uses change. When landscape management focuses only on those ecosystem services with the highest economic values, it leads to the conversion of ancient multifunctional landscapes into single-function land use types (de Groot, 2006). To counteract this type of land-use change, PAs are created. In the Doñana SES, 34,625 ha were declared as a National Park in 1969 to counteract the land-use change related to promoting agriculture and tourism that started in the middle of the 20th century. Additionally, the declaration of the Doñana National Park entailed changes in the institutions regulating the use of resources, which restricted the access of local users to provisioning services (Gómez-Baggethun and Kelemen, 2008). The implementation of this top-down conservation policy led to the emergence of conflicts between local users and conservationists (Ojeda, 1993). This encourages a *conservation against development* model (Folke, 2006), which is based on protecting biodiversity inside the PA and land use intensification surrounding the PA (Fig. 3). The main objective of PAs is to protect

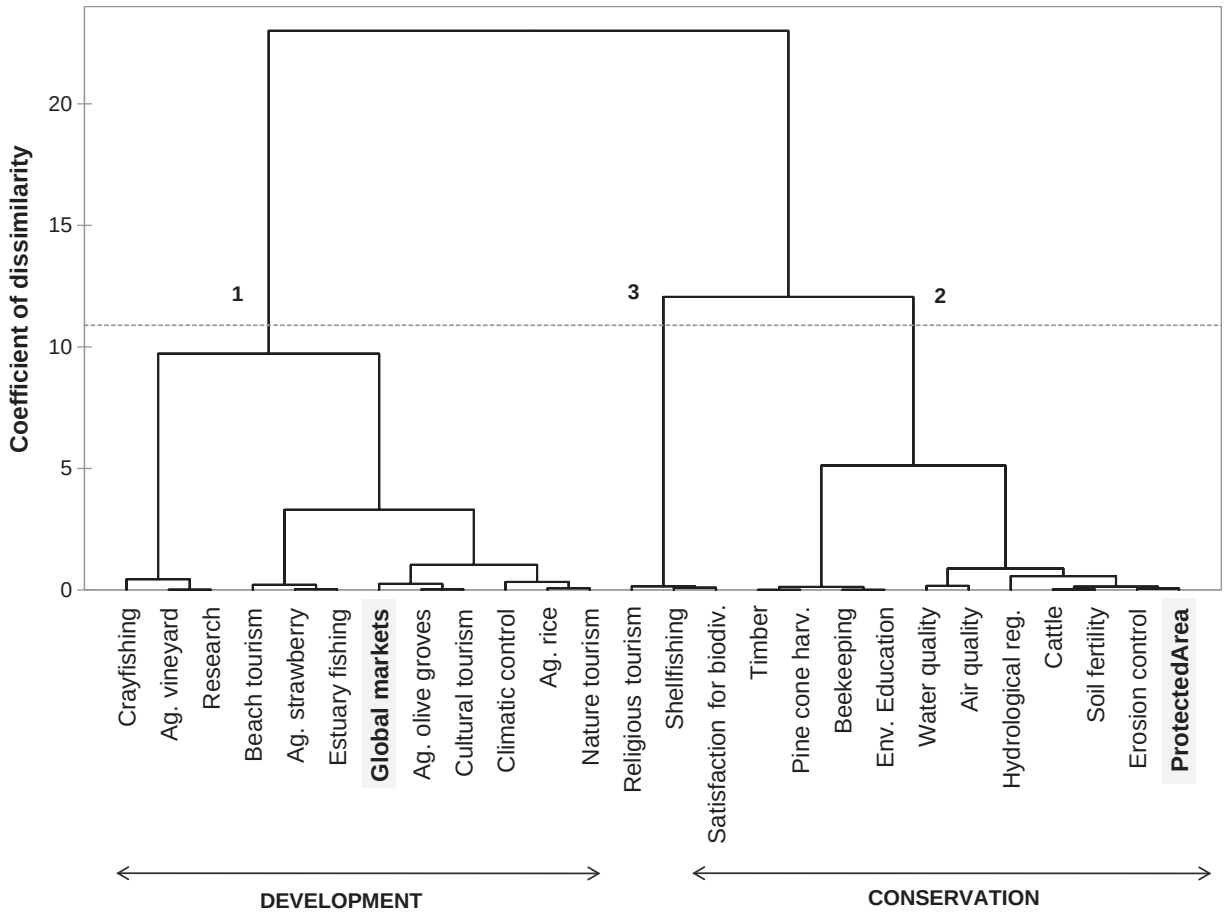

Fig. 3. Hierarchical cluster analysis of ecosystem services values. Three ecosystem services groups were identified, which represent a gradient from economic development (on the left) to biodiversity conservation (on the right).

species, habitats, and wild areas, sometimes without considering the views of local people. However, to avoid negative impacts of PA on human welfare in neighbouring communities outside the PA borders, the main objective is to promote economic development through agriculture, fisheries, and tourism (West et al., 2006). This model creates a territorial matrix composed of croplands and housing development at the borders of the PA and conservation inside the PA. In fact, although only 30% of land inside the Doñana PA has been transformed from 1956, more than 93% of land has been converted outside its borders (Fig. 1). Joppa et al. (2008) indicated that land use change surrounding PAs is occurring throughout the world.

This conservation model seems to ignore biophysical boundaries, such as ecodistricts, watersheds or aquifers (Fig. 1). When a larger ecosystem, as defined by hydrological boundaries (both superficial and subterranean), characterises areas outside the boundaries of an existing PA, it is unlikely that the PA can be protected without making compromises with the related social system (DeFries et al., 2007). In the Doñana SES, the socio-economic system outside of the PA prioritises those ecosystem services associated with national and global markets (i.e., agriculture, fisheries, and tourism; Fig. 2), negatively influencing the functioning of the ecosystem and, thus, its capacity to provide regulating services. For example, in increasing the net value of intensive agriculture (strawberry crops and rice fields), detrimental effects have occurred in regulating services both inside and outside the Doñana PA (soil fertility, erosion control, and water quality) due to high levels of pesticides, nitrogen, and phosphorous compounds (Olías et al., 2008; Tortosa et al., 2011; Vioque-Fernández et al., 2009). Furthermore, during the last 50 years, great degradation of hydrological regulation services has taken place due to intense sedimentation rates in the marshes, and this can be attributed to alterations and land-use changes in the upper watersheds (Rodríguez Ramírez et al., 2005).

Similarly, it has been demonstrated that increasing tourism has a negative impact on water quality and quantity because of the growth of coastal tourist resorts (Matalascañas and Mazagon; Fig. 1), implying an increase in water demand and, therefore, having a negative effect on the phreatic level of the aquifer (Custodio et al., 2009).

These results are consistent with those of previous studies that have demonstrated that when management of an SES focuses only on a few ecosystem services, particularly marketed services, trade-offs can create unwanted declines in the majority of ecosystem services (Bennett et al., 2009; Gordon et al., 2010).

5.2. Socio-Politics and Economic Drivers at a Larger-Scale Level of Governance Cause a Loss of Natural Capital in Protected Areas

Ecosystem services can be used and consumed by local, Andalusian, national or international customers and citizens. Landowners, producers and consumers (at different scales) are all beneficiaries of the ecosystem services production chain, but in different capacities. We found that in the Doñana SES, those provisioning services with higher economic values, i.e., intensive agriculture, fishing, or tourism, are mainly associated with national and international consumers (Fig. 2), promoting local dependence on foreign consumers' preferences. Being dependent on foreign consumers' preferences can leave the local economy vulnerable to outside influences. For example, although the strawberry sector is currently mature, strawberries are considered too risky because strawberry supplies have increased in Poland and southern Italy, and thus, farmers have started moving to new crops such as raspberries and citrus (Garrido et al., 2006).

Furthermore, the unsustainable use of land areas surrounding the Doñana PA affects the ecosystem's potential to provide other ecosystem services (mainly regulating), affecting beneficiaries at lower organisational scales.

Additionally, the private benefits of conversion are often exaggerated by intervention failures, such as environmentally harmful subsidies (e.g., Common Agricultural Policy) (de Groot, 2006). In Doñana, economic subsidies promote land use changes outside the PA, increasing pollution, erosion, and sedimentation rates in the marshes (see Section 4.1.1.2). As the values attached by users to regulating services do not play a direct role in the economic mechanisms in the region, some common-pool resources, such as groundwater and soil, are being overexploited due to an agricultural intensification process taking place outside the PA that is often fostered by market pressures and this type of subsidy (Gómez-Baggethun and Kelemen, 2008). However, these subsidies do not guarantee the acceptance of the PA because people continuously expect the implementation of new 'development plans' to generate a new economic upturn (Ojeda, 1993). Moreover, some subsidies can threaten social capital, which is essential for sustainable management of natural capital (Pretty, 2003). For example, the recent reform of European wine production has promoted vineyard abandonment, which entails the loss of traditional knowledge and its associated institutions (familiar farmers and cooperatives), both of which are considered indicators of social capital (Pretty and Smith, 2004).

Decades of uncoordinated policies from different sectors have strengthened the deeply rooted idea that local communities have a legitimate claim to compensation for renouncing the complete transformation of an area for intensive agriculture and tourism development (Voth, 2006). This 'culture of assistance' established in the population living around Spanish PAs has been denounced by some authors (e.g. Troitiño Vinuesa et al., 2005).

The reliance of the Doñana SES on global markets reflects a local-level vulnerability to changes in international market prices. Moreover, this international and national-scale dependence is threatening the natural capital of Doñana and the associated local management practices (Gómez-Baggethun et al., 2010). Understanding how these larger-scale economic drivers interact with the local social–ecological system is essential for informing the decision-making related to ecosystem services management and conservation needs.

5.3. Towards a Conservation Strategy Beyond Protected Areas

Although a large amount of funding has been allocated inside the Doñana PA (Martín-López et al., 2009b), the unsustainable resource use at its borders is reflected in the decline in mobile species (such as the charismatic Iberian lynx) and important market species (such as the glass eel), as well as higher levels of habitat fragmentation, contamination, and erosion (Fernández-Delgado, 2005). This is because this PA model ignores the territorial matrix in which it is embedded, and therefore, it becomes a drain on limited conservation resources.

Thus, human-modified landscapes will require a range of policy instruments, in addition to the implementation of traditional PAs to succeed (Daily and Matson, 2008). For the immediate future, PAs should be complemented with a tiered conservation strategy (Eigenbrod et al., 2010), in which agri-environmental incentives, payments for ecosystem services, or appreciation of local practices and knowledge should be included to maintain the socio-economic system.

A broad landscape management strategy that analyses the delivery and use of multiple ecosystem services should be designed to detect the main drivers of change underlying ecosystem degradation. Here, we extract knowledge from the economic valuation approach of ecosystem services through a holistic comprehension of their values, which can help to identify which indirect drivers of change underlie the degradation of the Doñana PA. In the Doñana SES, we found that the combination of two main indirect drivers of change (i.e., a *conservation against development* policy and international markets) underlies different direct drivers of change (i.e., mainly land-use change outside the Doñana PA, water and soil contamination, and water overharvesting) that lead to the degradation of regulating services. In fact, Fernández et al. (2010) demonstrated that land-use change in transformed land outside the Doñana PA is a key direct driver of changing biogeochemical processes at the local level.

PAs should be seen as being part of a larger-scale landscape (Bengtsson et al., 2003) in which conservation planning should be the focal element for coordinating sectoral policies that stimulate higher-value ecosystem services (agriculture, fisheries, and tourism). Conservation of PAs should not be viewed in isolation but should be embedded in a wider social–ecological systems management policy. The Biosphere reserves under the UNESCO Man and the Biosphere (MAB) programme have used this conceptual approach. However, the designation of Doñana as a Biosphere Reserve has not included the implementation of this approach. This mismatch between policy and practice may be attributable to knowledge gaps regarding human–nature interactions and to the absence of institutions that use available knowledge to influence decision-making policy regarding conservation (Persic et al., 2008).

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